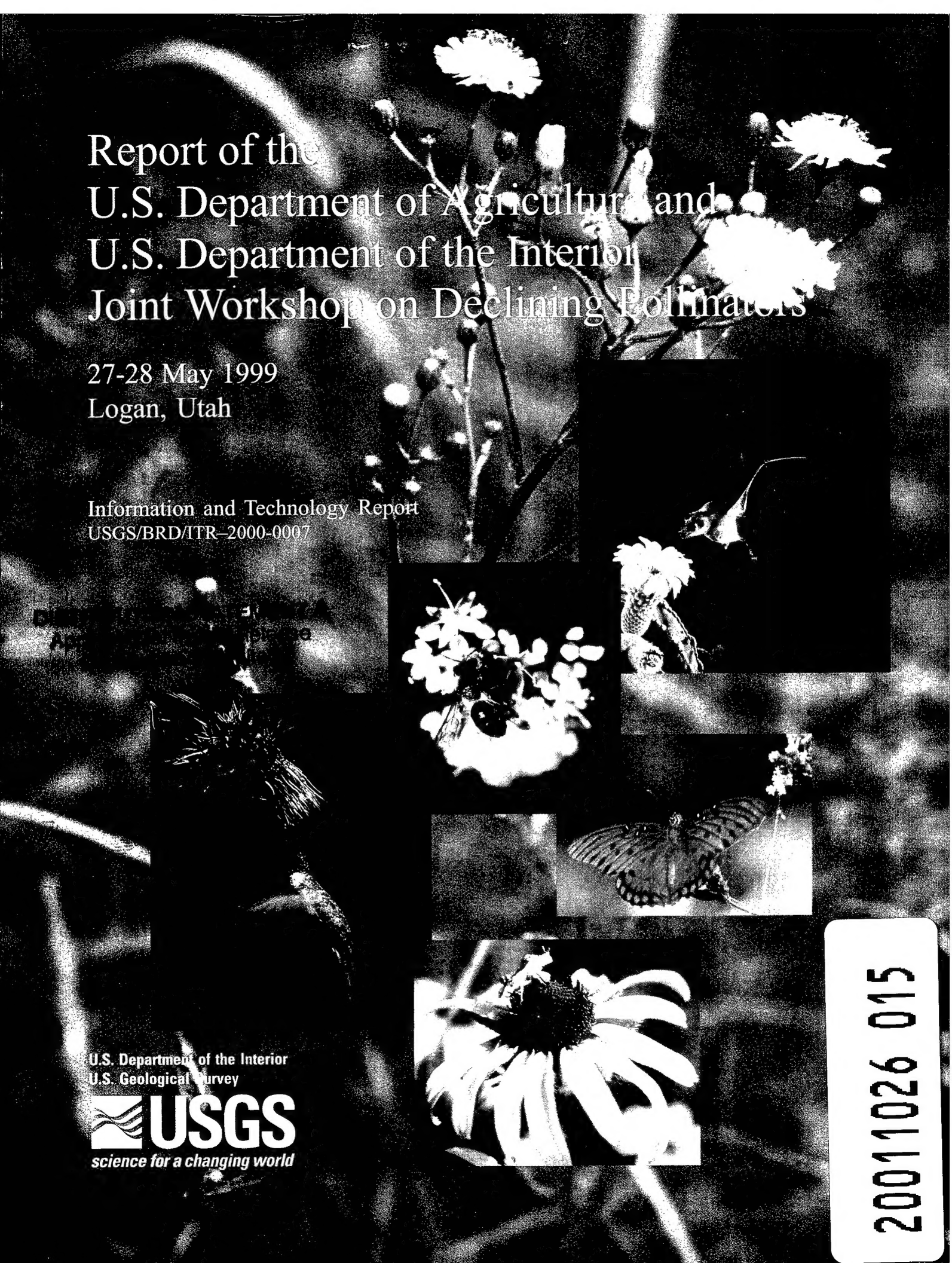

Report of the U.S. Department of Agriculture and U.S. Department of the Interior Joint Workshop on Declining Pollinators

27-28 May 1999
Logan, Utah

Information and Technology Report
USGS/BRD/ITR–2000-0007

U.S. Department of the Interior
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Cover photos: Background, smooth hawk's beard *(Crepis runcinata)*, Robert E. Stewart, Sr.; lesser long-nosed bat (*Leptonycteris curasoae*), Merlin D. Tuttle, Bat Conservation International; gulf fritillary (*Agraulis vanillae*), U.S. Geological Survey; ambush bug (*Phymata erosa*), Stephen R. Johnson, U.S. Geological Survey; broad-tailed hummingbird (*Selasphorus platycercus*), courtesy of U.S. Department of Agriculture and taken by Jack Dykinga; bee (*Andrena* sp.), Howard Ginsberg, U.S. Geological Survey.

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by

Vincent J. Tepedino and Howard S. Ginsberg

U.S. Department of the Interior
U.S. Geological Survey
Patuxent Wildlife Research Center

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9:45 a.m.	Lepidoptera as forgotten pollinators - Paul Opler, USGS, retired
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10:25 a.m.	Status of vertebrate pollinators in North American forests - Gary Paul Nabhan, Arizona Sonora Desert Museum
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11:05 a.m.	Invasive plants and pollination of native plants - Diane Larson, USGS
11:30 a.m.	Discussion: data gaps, research needs, and areas of collaboration (James Thomson, State University of New York, Stony Brook)
12:30 p.m.	Lunch

Developing a joint research strategy for USDOI and USDA

1:30 p.m.	Research strategy and development of budget initiatives on pollinator declines - Mike Ruggiero, USDOI, and Bob Vander Meer, USDA, moderators
3:00 p.m.	Break
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4:30 p.m.	Summary and closing remarks - Denny Fenn, USGS, and Will Blackburn, USDA
5:00 p.m.	Adjourn

Evening activity

8:00 p.m.	Informal tour of USDA Bee Biology and Systematics Laboratory

Executive Summary

A workshop was held on 27-28 May 1999 in Logan, Utah, to assess current knowledge on the status of pollinator populations and to recommend research directions for the U.S. Department of Agriculture (USDA) and the U.S. Department of the Interior (USDOI). The 24 participants included federal scientists and selected university and museum researchers. Presentations emphasized evidence of possible declines in pollinator populations, factors impacting pollinators, the effects of changes in pollinator service on natural and agricultural systems, and management approaches to deal with changing pollinator faunas.

The participants identified seven broad issues relevant to pollinator declines, as well as numerous research needs associated with these issues. The seven issues were (1) the relationship between pollination and ecosystem health; (2) landscape-level patterns of pollination (especially along a cline from wild lands to agricultural, suburban, and urban environments); (3) multiple factors that simultaneously influence pollinator populations (such as habitat fragmentation, pesticides, and invasive species); (4) bioprospecting (e.g., among wild pollinators for potentially valuable agricultural pollinators) and biodiversity; (5) development of restoration and management practices for pollinators; (6) public education about the importance of pollinators; and (7) implications of pollination considerations for policy options.

Research is recommended on several topics associated with these issues:

Monitoring. Long-term monitoring programs should be established for feral honeybees and selected native pollinator species.

Biological survey. Pollinators and plant-pollinator relationships should be surveyed and compared among natural, agricultural, suburban, and urban environments.

Taxonomy/systematics. Additional resources, including full-time equivalent employees, need to be applied to taxonomy and systematics of pollinators, especially bees.

Roles of pollinators in natural and agricultural systems. Research is needed to establish the values of wild pollinators to natural systems and for crop production. The potential effects of changes in pollinator populations on natural communities and on agricultural productivity need to be assessed as well.

Restoration. Study is needed on management methods to restore pollinator populations that have been extirpated or artificially modified.

Report of the U.S. Department of Agriculture and U.S. Department of the Interior Joint Workshop on Declining Pollinators

27-28 May 1999
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by

Vincent J. Tepedino
U.S. Department of Agriculture
Agricultural Research Service
Bee Biology and Systematics Laboratory
Utah State University
5310 Old Main Hill
Logan, Utah 84322-5310

Howard S. Ginsberg
U.S. Geological Survey
Biological Resources Division
Patuxent Wildlife Research Center
University of Rhode Island
Woodward Hall–PLS
Kingston, RI 02881-0804

Abstract: Pollinators such as bees, birds, and bats are important components of agricultural and natural ecosystems. Current evidence suggests that populations of some pollinators are declining because of habitat loss and fragmentation, pesticide use, and the effects of invasive species. The U.S. Department of Agriculture and the U.S. Department of the Interior held a joint workshop on declining pollinators to assess the current status of pollinator populations and to recommend research directions for their agencies. The two-day workshop on 27-28 May 1999 in Logan, Utah, included presentations by federal scientists and university and museum researchers on the evidence and causes of pollinator declines and on resulting problems for agriculture, changing patterns in pollination of wild plants, and implications for natural communities. The participants discussed research needs and joint research strategies for both agencies. Important recommendations included establishing monitoring programs to assess trends in pollinator populations, conducting biological surveys of pollinators, fostering study of bee systematics, assessing the roles of pollinators in natural and agricultural systems, and restoring pollinator habitat.

Key words: Pollinators, agricultural ecosystems, natural ecosystems, monitoring, pollinator populations, bee systematics

Introduction

On May 27th and 28th, federal scientists and administrators and selected university researchers convened in Logan, Utah, under the auspices of the USDA and USDOI to discuss the implications of pollinator decline for natural systems and agrosystems (see Agenda and List of Participants). Presentations were made on the status of feral, domesticated, and semidomesticated populations of the honeybee (*Apis mellifera*), bumblebees (*Bombus* sp.), several species of "solitary" bees, and vertebrate pollinators such as bats (Chiroptera). Special attention was given to changes in the population numbers of these important pollinators and their potential effects on agriculture and natural communities.

Pollinators play an important role in natural systems by mediating sexual reproduction in plant populations. They thereby exert direct effects on plant demography and population genetics, and on plant community composition, and they exert indirect effects on all higher trophic level organisms that use plants for food or shelter. Pollinators are also important in agriculture because of their direct influence on fruit and seed yield of many crops. The recent book, *The Forgotten Pollinators* (Buchmann and Nabhan 1996), has drawn attention to likely declines in pollinator populations and sounded a warning call about the potential implications of these declines. Soon after, the Society for Conservation Biology published a position paper (Allen-Wardell et al. 1998) examining the potential implications of pollinator declines and calling for additional research on this issue. The possible causes and implications of changes in pollinator populations have also received some attention in the scientific literature (e.g., LaSalle and Gauld 1993; Matheson et al. 1996; Butz Huryn 1997; Kearns et al. 1998; Kevan 1999), but solid evidence on the occurrence and implications of pollinator declines remains thin.

Summary of Presentations

Current evidence suggests that it is not at all clear that honeybee populations are continuing to decline because of Varroa mites (*Varroa jacobsoni*) and tracheal mites (*Acarapis woodi*) (Visscher; see Agenda). Indeed, there is a bit of preliminary evidence from a few scientists to suggest that feral populations may have begun to rebound; however, quantitative data on national trends in feral honeybee populations are generally lacking. The Africanized honeybee (AFB) may be in a secondary breakout stage after several years of population semistasis: AFB's appear to be advancing north at more rapid rates than in recent years from beachheads in southern Arizona, California, and Texas and represent a potential problem for agricultural crops that require pollinators. For most areas of the country, the data to answer important questions about honeybee population dynamics are not available and are not being collected.

The use of bumblebees for greenhouse pollination, especially crops of the Solanaceae family such as tomatoes, peppers, and eggplants, is increasing (Thorp; see Agenda), but bumblebees (*Bombus occidentalis* in particular) are no longer being commercially produced on the west coast. Instead, the eastern species *Bombus impatiens* has been cleared for importation into many western states for agricultural use in large greenhouses. Even more recently, the aggressive Middle Eastern species, *Bombus terrestris*, has been imported into Mexico, where it could potentially escape into North America. Natural bumblebee populations are not being monitored for population trends, but it was generally agreed that their populations likely continue to fluctuate widely in response to a variety of abiotic and biotic conditions.

Solitary bees, both natives and accidental introductions, are playing a growing role in the pollination of agricultural crops (Cane, Bosch; see Agenda). In addition to time-tested alfalfa pollinators such as the alfalfa leafcutting bee (*Megachile rotundata*) and the alkali bee (*Nomia melanderi*), other natives such as the blue orchard bee (*Osmia lignaria*), a related blueberry bee (*Osmia ribifloris*), and the sunflower leafcutting bee (*Megachile pugnata*) are in the pipeline for future delivery to growers. Although research on commercial propagation of these species is in progress, currently the only major source of these species of bees is lands managed by the USDA Forest Service, by the USDOI (primarily Bureau of Land Management [BLM]) and by other federal agencies. Thus, conservation and stewardship of our native bee species on federal lands is of great importance to our effort to develop supplementary and alternative crop pollinators.

Among the threats to native bee populations, and, indirectly to the crops and native plants they pollinate, are pesticides, especially broad-spectrum insecticides and herbicides (Kevan; see Agenda). Toxicological information on the effects of most insecticides on native solitary bee species is mostly unavailable, and we must make inferences from results of studies on more readily available species such as the honeybee. This is a less than completely reliable tactic since it has been shown that species such as the alfalfa leafcutting bee and the alkali bee have insecticide sensitivities that differ somewhat from those of the honeybee. Herbicides affect bees indirectly by destroying pollen and nectar sources supplied by native and introduced flowering plants.

Another important threat to bee populations, particularly to the undomesticated native species responsible for

pollinating our native flora, as well as to those with potential as supplementary crop pollinators, is habitat loss and fragmentation (Tepedino, Nabhan; see Agenda). Habitat loss, that is, conversion of natural areas to places of human habitation, industry, or commerce, poses an immediate and frequently irreversible threat to pollinators. Studies of the effects of habitat fragmentation on other insect groups, and on vertebrates, are not necessarily applicable to bees because of their distinct biology: bees are central place foragers whose food and shelter needs may require them to travel long distances from nest to food, water, and structural resources.

Other threats discussed included a variety of introduced species, both plants and animals, which negatively interact both directly and indirectly with native pollinators and with the plants they service (Canfield, Larson; see Agenda). For example, invasive species have had profound effects on the Hawaiian fauna and flora, and extraordinary efforts are currently required to provide pollinator service to rare native plant species. Unmentioned, but nevertheless with important impacts on insect pollinators, are livestock (as grazers of food plants, tramplers of bee nest sites, and actors encouraging broad-spectrum insecticide spraying for grasshoppers on federal rangelands); removal of stumps, slash, snags, and other potential wood nesting sites from intensely managed forest lands; and uncontrolled use of off-road vehicles, which cause erosion, alter plant species composition, and render areas unacceptable to ground-nesting bees through soil compaction and obliteration, especially during the nesting season.

Trends in insect pollinator populations and faunas are statistically difficult to document, but innovative approaches are being developed to assess changes in pollinator faunas through time (Sauer; see Agenda). We tentatively concluded that although evidence is slim and mostly from non-North American examples (Buchmann; see Agenda), insect pollinator declines are likely, at the very least, in areas with high levels of human activity. Populations of selected butterfly species are likely among those that have declined. The importance of butterflies as pollinators, however, in either natural systems or agroecosystems has not been demonstrated (Opler; see Agenda). Declines in vertebrate pollinator populations, particularly migratory bird species and bats, appear to be better documented (Nabhan, Bogan; see Agenda). Maintenance of migration corridors is important to maintain populations of migratory vertebrate pollinator species. Compared to insect pollinators, these vertebrate pollinators have relatively little importance for major agricultural cash crops in North America but are important in natural systems in arid southwestern North America and in tropical areas in Mexico and Central America.

Numerous suggestions for research on pollinators and the plants they visit were offered during a scoping session that ended the workshop (Ruggiero and Vander Meer; see Agenda). We have tried to distill from those many suggestions what we feel are the most important research questions that can benefit both USDA and USDOI. Many research topics mentioned during the session are better explored by one of the agencies alone or by collaboration with university scientists. In this report, we restrict our suggestions to the areas of monitoring, biological survey, study of the roles of pollinators in natural and agricultural systems, and restoration.

Issues and Research Needs

The workshop participants identified seven general issues associated with pollinator declines that require special attention. Research needs associated with each issue were compiled.

(1) Pollination and Ecosystem Health

Changes in pollinator populations undoubtedly influence plant populations and thus natural communities, but little information is available about long-term trends in pollinator faunas and the effects of these trends on ecosystem processes. Research needs identified with this issue area are listed in Box 1. Priorities include establishing monitoring programs to assess patterns of change in pollinator numbers and diversity, and determining which plant species are pollinator-limite (especially endangered species) so as to assess vulnerability of natural systems to pollinator decline.

(2) Landscape Scale and Patterns

Important landscape-level factors that influence pollinator populations include habitat fragmentation, loss, conversion, and land-use patterns. Research needs associated with landscape-scale effects are listed in Box 2. Research on changes in pollinator faunas, and resulting effects on the dynamics of pollination systems along a cline from wild lands to agricultural, suburban, and urban areas would be particularly valuable. In addition, the importance of preservation of "nectar corridors" for migratory pollinators (e.g., sites along migration routes of bird and bat pollinators) for maintenance of pollinator populations needs to be assessed. Preservation of crucial sites can be incorporated into conservation plans and resource management programs on federal lands.

Box 1. Research Needs: Pollination and Ecosystem Health

- Monitor long-term changes in pollinator guilds
- Assess effects of changes in pollinator service on ecosystems
- Examine value of pollinator redundancy for stability of natural systems
- Assess whether plants are pollinator-limited; assess pollination deficits in:
  (a) natural systems in general
  (b) rare and endangered plant species
  (c) agroecosystems
- Identify model ecosystems and appropriate sites for research
- Delineate ecosystem services provided by pollinators
- Identify vulnerabilities in plants or ecosystems to pollinator declines
- Examine the question of what is a "healthy" ecosystem for pollinators
- Compile additional information on floral host associations of pollinators
- Assess spatiotemporal variability in pollinator assemblages and its effect on plant reproduction

Box 2. Research Needs: Landscape Scale and Patterns

- Study pollination dynamics (including plants) at the agriculture–wild land interface (including urban–suburban areas)
- Assess the role of nectar corridors; identify and map corridors, study the required configuration of corridors for migratory species
- Study the effects of landscape fragmentation on pollinator populations and plant pollination
- Study how pollinator movements link landscape units
- Predict effects of pollinator declines on landscape-level patterns
- Assess how differences in pollinator guilds influence productivity in different parts of a plant's range
- Assess the effects of size and distribution of plant populations on pollinator communities
- Examine the effects of invasive plant species on pollinator movement in landscapes
- Evaluate the potential contribution of invasive plant species to increases in pollinator populations

(3) Multiple Factors

Numerous factors drive trends in pollinator populations, including invasive species, pathogens, pesticides, genetically modified organisms, habitat fragmentation and loss, distribution and phenology of flower bloom, etc. Often, multiple factors operate simultaneously to stress, or to enhance, pollinator populations. Research needs identified in this area are listed in Box 3. The effects of interaction of multiple drivers on pollinator populations, and the relationships between native pollinators and introduced plants, are of particular importance.

(4) Bioprospecting and Biodiversity

The rich native bee fauna of North America provides an extensive resource for "bioprospecting" for potentially valuable crop pollinators. An essential first step is to describe this fauna, so resources need to be applied to systematic study of pollinators. Development and integration of computer databases, and of associated methods to identify pollinators, would be invaluable. Study on the potential effects of bioprospecting on natural populations is also important. Research needs are listed in Box 4.

(5) Restoration and Management Practices

Real-world application of basic knowledge about pollinators, their interactions with plants, and associated ecosystem and landscape-level effects, will require practical knowledge about techniques to restore pollinators and to preserve their habitats. Research questions about restoration and management are listed in Box 5. Improved propagation techniques for pollinators and their host plants would clearly be valuable. Homeowners, local associations, and park

Box 3. Research Needs: Multiple Factors

- Study effect of habitat fragmentation on pollinator dynamics and plant reproduction
- Evaluate effects of interaction of multiple stresses on pollinators
- Develop integrated pest management for pests of managed pollinators
- Examine interactions of invasive plant species, native plants, and pollinator guilds
- Study pesticide effects on native pollinators
- Evaluate the potential use of nonnative pollinators for native plants
- Develop decision support systems for screening potential invasives
- Assess the effects of genetically modified organisms on pollinators
- Assess the potential effects of climate change and extreme events on pollinator populations

Box 4. Research Needs: Bioprospecting and Biodiversity

- Enhance taxonomic capabilities in USDA and USDOI
- Complete the publication, "Bees of North America"
- Comprehensively compile the publication, "Pollinators of North America"
- Examine the effects of bioprospecting
- Accelerate release of candidates for crop pollination
- Enhance technology transfer to agriculture
- Assess and demonstrate value of set-aside lands for pollinators
- Determine relative pollination efficiency of various taxa for insect-pollinated crops
- Enhance bioprospecting and screening of surrogate pollinators, including foreign prospecting
- Develop a gap analysis program for pollinators
- Develop and integrate museum databases
- Evaluate use of pollinators for biomonitoring for agricultural and wild lands
- Develop new bee identification tools

Box 5. Research Needs: Restoration and Management Practices

- Evaluate critical habitat size for pollinators and host plants
- Develop propagation techniques for pollinators and host plants
- Study impacts of disturbance on pollinators (fire, grazing, etc.)
- Evaluate conflicts of management practices on pollinators
- Develop methods for control of invasives
- Develop bee garden methodologies and methods for habitat enhancement for pollinators (roadsides, hedgerows, golf courses, etc.)
- Develop methods to reintroduce pollinators to restored lands and mitigated habitats
- Study interactions of multimanaged pollinator species
- Develop criteria to evaluate restorations (relative to pollination)
- Monitor restoration programs
- Assess impacts of introduced pollinators on genetic diversity of native pollinators
- Assess influence of public attitudes and behaviors on restoration

and golf course managers, for instance, can potentially participate in pollinator enhancement programs (e.g., by planting flowers that provide nectar and pollen during periods of flower dearth) once optimal management methods have been developed. Research is recommended on the effects of current management practices on pollinators and on potential alternatives for practices that have adverse effects on pollination systems.

(6) Education

The research projects outlined in the previous sections can provide information useful to scientists and resource managers for dealing with potential pollinator declines. It is essential that people outside these professional communities be aware of the importance of pollinators in natural ecosystems and in agriculture. Furthermore, participation by the general public is essential to the success of broad-scale conservation programs for pollinators. There are numerous opportunities in the recommended projects for educational programs on pollinators and for public participation in data-collecting and in pollinator conservation programs.

(7) Policy Options

Results of the research studies outlined here have implications for decisions about policy options in both the USDA and the USDOI. The information and understanding resulting from these studies will provide guidance in selecting alternative management practices on federal lands.

Research Recommendations

Monitoring trends in pollinator populations. We recommend establishing a national system for the long-term monitoring of pollinators, including feral honeybees, selected native and perhaps introduced bee species, and important vertebrate pollinators. The details of this monitoring scheme remain to be worked out but should include all areas of the country as well as representative species from diverse taxa with different nesting behaviors (e.g., twig-nesters, ground-nesters, etc.) and different degrees of host-specificity. Monitoring should be coupled with research projects designed to assess the effects of multiple driving factors on populations of pollinator species.

Biological survey. Surveys of the occurrence and distribution of bees, especially comparisons of species in urban, suburban, rural, and "natural" surroundings, are essential to better understand the effects of anthropogenic activity on pollinating bees. Native solitary bee species are receiving increasing attention as pollinators in agroecosystems. The populations we obtain to conduct our experiments, and the species that will eventually pollinate selected crops, can most readily be found on federal land administered by USDA (Forest Service) and USDOI. To facilitate obtaining populations for research and eventual commerce, we need a survey of populations in their natural surroundings that will provide us with detailed information on bee species distributions together with their host plant preferences.

Taxonomy/systematics. Neither monitoring nor surveys are feasible without increased attention to specimen curation and identification. Taxonomy/systematics is the very base that supports all the other research recommendations we make here. We recommend that FTE's be allocated to hire Ph.D.-level systematists to extend our currently crude understanding of bee systematics and to handle the overwhelming specimen-identification load for bee taxonomists. We also suggest the training of parataxonomists to handle routine identifications of specimens for research and monitoring programs.

Role of natural pollinators in natural and agricultural systems. The roles of native bee pollinators in natural and agricultural ecosystems need to be clearly assessed. Such assessments will allow us to provide well worked-out examples of the value of biodiversity in general, and pollinators specifically, in ecosystem function and in agricultural productivity.

(a) *Natural systems*. In natural systems, pollinators act as keystone mutualists whose activities are necessary for the sexual reproduction of roughly two-thirds of flowering plants and, in turn, for the growth and survival of animals that harvest all, or parts, of those plants for their food and for the food of their progeny. For example, a large proportion of all North American bird species use fruits and seeds for food at some time in their yearly cycles. We should attempt actual research-based estimates of this value. Furthermore, any change in pollinator service to plants (resulting from declines in pollinator populations, introduction of nonnative pollinator species, or spread of invasive plant species) can change trends in plant reproduction, and thus have potentially broad effects on natural communities. Research is needed on these potential secondary effects of changing patterns of pollinator service in natural communities.

(b) *Agricultural systems*. We need to evaluate the value of bee species as pollinators of backyard garden crops, and of crops that are grown adjacent to or near federal wild lands or private set asides such as conservation reserve program land. Thus, we envision a series of collaborative studies that evaluate the importance of natural pollination to a variety of agricultural crops grown in environs that vary in ecological diversity.

Restoration. While estimating the value of bee pollinators, we must also demonstrate effective techniques for restoring pollinator habitat that has been destroyed or modified. Myriad possibilities exist for potential restoration of native plants and pollinators on small and intermediate-sized scales. Some of these are already being explored in a modest way, and these studies should be expanded. Examples include habitat restoration in urban parks and monuments, especially those administered by USDOI, private golf courses, industrial parks, hospital grounds, apartment complexes, and college and university grounds.

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List of Participants

Wilbert H. Blackburn
Northern Plains Area Director
U.S. Department of Agriculture, Agricultural Research Service
1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525-5562
970-229-5557
Fax: 970-229-5565
blackbuw@ars.usda.gov

Michael A. Bogan
Project Leader, Aridland Studies
U.S. Geological Survey, Biological Resources Division
Museum of Southwest Biology
University of New Mexico
Albuquerque, NM 87131
505-346-2870 Ext. 12
Fax: 505-277-0304
mbogan@unm.edu

Jordi Bosch Gras
Research Entomologist
U.S. Department of Agriculture, Agricultural Research Service
Bee Biology and Systematics Laboratory
Utah State University
5310 Old Main Hill
Logan, UT 84322-5310
435-797-2588
Fax: 435-797-0196
Nomada@cc.usu.edu

Stephen Buchmann
Research Entomologist
U.S. Department of Agriculture, Agricultural Research Service
Current address:
The Bee Works
1870 West Prince Rd., Suite 16
Tucson, AZ 85705
520-888-7422
Fax: 520-888-7332
steve@thebeeworks.com

James H. Cane
Research Entomologist
U.S. Department of Agriculture, Agricultural Research Service
Bee Biology and Systematics Laboratory
Utah State University
5310 Old Main Hill
Logan, UT 84322-5310
435-797-3879
Fax: 435-797-0461
jcane@biology.usu.edu

Joan E. Canfield
Federal Unit Leader and Supervisory Biologist, Pacific Cooperative Studies Unit
U.S. Geological Survey, Biological Resources Division
Pacific Island Ecosystems Research Center
University of Honolulu
Department of Botany, St. John Laboratory
3190 Maile Way, Room 410
Honolulu, HI 96822
808-956-8820
Fax: 808-973-2936 or 808-956-5687
joan_canfield@usgs.gov

Paul H. Dunn
National Program Manager, Vegetation Management and Protection Research
U.S. Department of Agriculture, Forest Service
Research and Development
P.O. Box 96090
Washington, DC 20090-6090
202-205-1659
Fax: 202-205-6207
Paul.Dunn/wo@fs.fed.us

Dennis B. Fenn
Chief Biologist
U.S. Geological Survey, Biological Resources Division
12201 Sunrise Valley Drive, MS 300
Reston, VA 20192
703-648-4050
Fax: 703-648-4042
Denny_Fenn@usgs.gov

Howard S. Ginsberg
Ecologist
U.S. Geological Survey, Biological Resources Division
Patuxent Wildlife Research Center
University of Rhode Island
Woodward Hall – PLS
Kingston, RI 02881
401-874-4537
Fax: 401-874-5296
hsgnsbg@uriacc.uri.edu

William P. Gregg
U.S. Geological Survey, Biological Resources Division
12201 Sunrise Valley Drive
Reston, VA 20192
703-648-4067
Fax: 703-648-4039
william_gregg@usgs.gov

Terry L. Griswold
Research Entomologist
U.S. Department of Agriculture, Agricultural Research Service
Bee Biology and Systematics Laboratory
Utah State University
5310 Old Main Hill
Logan, UT 84322-5310
435-797-2526
Fax: 435-797-0461
tgris@cc.usu.edu

James L. Hanula
Research Entomologist
U.S. Department of Agriculture, Forest Service
Southern Research Station Forestry Sciences Laboratory
320 Green Street
Athens, GA 30602-2044
706-559-4253
Fax: 706-559-4287
jhanula/athens_srs@fs.fed.us

William P. Kemp
Research Leader
U.S. Department of Agriculture, Agricultural Research Service
Bee Biology and Systematics Laboratory
Utah State University
5310 Old Main Hill
Logan, UT 84322-5310
435-797-2525
Fax: 435-797-0461
wkemp@cc.usu.edu

Peter G. Kevan
Professor
Department of Environmental Biology
University of Guelph
Guelph, Ontario N1G 2W1 Canada
519-824-4120 Ext. 2479
Fax: 519-837-0442
pkevan@uoguelph.ca

Diane L. Larson
Research Biologist
U.S. Geological Survey, Biological Resources Division
Northern Prairie Wildlife Research Center, Minnesota Field Station
University of Minnesota
100 Ecology Bldg., 1987 Upper Buford Circle
St. Paul, MN 55108
612-625-9271
Fax: 612-624-6777
dlarson@biosci.umn.edu

Gary Paul Nabhan
Director of Conservation Biology
Arizona-Sonora Desert Museum
2021 North Kinney Road
Tucson, AZ 85743
520-883-3007
Fax: 520-883-2500
gnabhan@desertmuseum.org

Paul A. Opler
U.S. Geological Survey, retired
Department of Bioagricultural Science
Colorado State University
Fort Collins, CO 80523
970-667-8448
Fax: 970-226-9230
paulevi@webaccess.net

Michael A. Ruggiero
Integrated Taxonomic Information System Coordinator
U.S. Department of the Interior
Washington, DC 20240
202-786-3117
ruggiero.michael@nmnh.si.edu

John R. Sauer
Wildlife Biologist
U.S. Geological Survey, Biological Resources Division
Patuxent Wildlife Research Center
11510 American Holly Drive
Laurel, MD 20708-4017
301-497-5662
Fax: 301-497-5666
john_r_sauer@usgs.gov

Vincent J. Tepedino
Research Entomologist
U.S. Department of Agriculture, Agricultural Research Service
Bee Biology and Systematics Laboratory
Utah State University
5310 Old Main Hill
Logan, UT 84322-5310
435-797-2559
Fax: 435-797-0461
andrena@cc.usu.edu

James D. Thomson
Professor
Department of Ecology and Evolution
State University of New York
Current address:
Department of Zoology
University of Toronto
Toronto, Ontario M5S 3G5 Canada

Robbin W. Thorp
Professor Emeritus
Department of Entomology
University of California, Davis
One Shields Avenue
Davis, CA 95616-8584
530-752-0482 or 752-9464
Fax: 530-752-1537
rwthorp@ucdavis.edu

Robert K. Vander Meer
Acting National Program Leader
U.S. Department of Agriculture, Agricultural Research Service
National Program Staff
Mailstop 5138
5601 Sunnyside Avenue
Beltsville, MD 20705-5134
301-504-4622
Fax: 301-504-5467
rvm@ars.usda.gov

P. Kirk Visscher
Professor
Department of Entomology
University of California, Riverside
Riverside, CA 92507
909-787-3973 or lab 787-3550
Fax: 909-787-3086
visscher@mail.ucr.edu

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Pollinators such as bees, birds, and bats are important components of agricultural and natural ecosystems. Current evidence suggests that populations of some pollinators are declining because of habitat loss and fragmentation, pesticide use, and the effects of invasive species. The U.S. Department of Agriculture and the U.S. Department of the Interior held a joint workshop on declining pollinators to assess the current status of pollinator populations and to recommend research directions for their agencies. The two-day workshop on 27-28 May 1999 in Logan, Utah, included presentations by federal scientists and university and museum researchers on the evidence and causes of pollinator declines and on resulting problems for agriculture, changing patterns in pollination of wild plants, and implications for natural communities. The participants discussed research needs and joint research strategies for both agencies. Important recommendations included establishing monitoring programs to assess trends in pollinator populations, conducting biological surveys of pollinators, fostering study of bee systematics, assessing the roles of pollinators in natural and agricultural systems, and restoring pollinator habitat.

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USGS-National Wetlands Research Center
Technology & Informatics Branch

Chief
Gaye S. Farris

Production Staff

Editors Tammy Charron, (Johnson Controls World Services)
Rhonda F. Davis
Beth A. Vairin

Layout/Coverdesign/ Printing Liaison Susan M. Lauritzen

U.S. Department of the Interior
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National Wetlands Research Center

Production Staff

Chief, Technology & Informatics Branch Gaye S. Farris

Writer/Editor Beth A. Vairin

Visual Information Specialist Susan M. Lauritzen

Editorial Assistant Rhonda F. Davis

Other Production Assistance

Technical Editor Tammy Charron, Johnson Controls World Services